UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/695,190	10/28/2003	Masahiko Tsukuda	AOY-3970US	4306

23122 7590 09/13/2006

RATNERPRESTIA
P O BOX 980
VALLEY FORGE, PA 19482-0980

EXAMINER	
BIBBINS, LATANYA	

ART UNIT	PAPER NUMBER
2633	

DATE MAILED: 09/13/2006

Please find below and/or attached an Office communication concerning this application or proceeding.

UNITED STATES DEPARTMENT OF COMMERCE
U.S. Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450

APPLICATION NO./ CONTROL NO.	FILING DATE	FIRST NAMED INVENTOR / PATENT IN REEXAMINATION	ATTORNEY DOCKET NO.
10/695,190	10/28/2003	Tsukuda	AOY-3970US

EXAMINER	
LaTanya Bibbins	
ART UNIT	**PAPER**
2633	20060906

DATE MAILED:

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner for Patents

Attached is the translation of JP 06-003115 requested by applicant's representative on August 22, 2006.

SHANON A. FOLEY
SUPERVISORY PATENT EXAMINER

PTO-90C (Rev.04-03)

PTO 06-6583

Japanese Kokai Patent Application
No. Hei 6[1994]-3115

SPECIMEN HEIGHT-MEASURING DEVICE

Genya Matsuoka et al.

UNITED STATES PATENT AND TRADEMARK OFFICE
WASHINGTON, D.C. SEPTEMBER 2006
TRANSLATED BY THE MCELROY TRANSLATION COMPANY

JAPANESE PATENT OFFICE
PATENT JOURNAL (A)
KOKAI PATENT APPLICATION NO. Hei 6[1994]-3115

Int. Cl.[5]:	G 01 B 11/02 H 01 L 21/027 H 01 L 21/30
Sequence Nos. for Office Use:	8708-2F 8831-4M
Filing No.:	Hei 6[1992]-160615
Filing Date:	June 19, 1992
Publication Date:	January 11, 1994
No. of Claims:	3 (Total of 4 pages)
Examination Request:	Not filed

SPECIMEN HEIGHT-MEASURING DEVICE

[Shiryo takasa keisoku sochi]

Inventors:	Genya Matsuoka et al.
Applicant:	Hitachi, Ltd.

[There are no amendments to this patent.]

Claims

1. A specimen height-measuring device that determines the height of a specimen by shining a light on a specimen to determine the height of the aforementioned specimen from the location of the reflected light, which specimen height-measuring device is characterized by calibrating using two reference surfaces of different heights and an inclined surface.

2. The specimen height-measuring device disclosed in Claim 1 that calibrates using a reference surface with 3 or more different surface heights.

3. Electron beam lithography equipment that possesses the aforementioned specimen height-measuring device disclosed in Claim 1 or 2.

Detailed explanation of the invention

[0001]

Industrial application field

The present invention pertains to a height-measuring device that measures changes in the height of a specimen, and to electron beam lithography equipment that possesses a height-measuring device.

[0002]

Prior Art

In electron beam lithography equipment, changes in the height of the specimen, i.e., changes in the distance from the electron beam deflectors to the specimen surface, greatly affect lithography precision. Figure 1 is an explanatory diagram of the relationship between changes in specimen height and lithographic precision in electron beam lithography. This figure is used to show an example of a case in which an electron beam 101 is deflected by an angle 2θ by a deflector 102 in order to draw a pattern on a specimen 103 at a height s1. Assuming that the specimen drops by a height Δh to a position 103' during lithography, the length of the pattern being drawn becomes s2 and the resulting drawing error becomes $2*\Delta x$. Where d is the distance from the point of deflection of the electron beam to the specimen, the relationship between the shift in height Δh and the drawing error is

[0003]

[Equation 1]
$$\begin{aligned}\Delta x &= \Delta h * \tan\theta \\ &= \Delta h * s1/(2*d).\end{aligned}$$

[0004]

Thus, in order to prevent drawing error caused by positional changes in the specimen in electron beam lithography equipment, the height of the specimen is measured and the result is output to and reflected in the control circuit that deflects the electron beam. Height-measuring devices that are normally used are configured as shown in Figure 2. Namely, light from a light-emitting element, such as a laser diode, etc., is shone onto a specimen 103 from an inclined direction, and the reflected light is incident to a position sensor 202. Since a signal is obtained from the position sensor 202 that is dependent on the position of the reflecting surface, the height of the specimen is found by processing the signal with an operation circuit.

[0005]

Since the signal intensity of the position sensor 202, as well as the characteristics of the amplifiers and dividers, etc., contained in the processing circuit that processes said signal, are all constant in this height-measuring device, periodic calibration is required.

[0006]

The conventional calibration method used will be explained using Figure 3. This figure shows the schematic configuration of the specimen table in electron beam lithography equipment, wherein there is a specimen cassette 302 loaded with specimens 303 on the specimen table 301. Furthermore, a step height reference 304 is provided in a portion of the specimen table as a reference. This step height reference has surfaces of two different heights (surface L, surface H), of which surface L indicates the height to be used for reference, i.e., the position at height 0 μm. Calibration of the height-measuring device comprises using the height-measuring device to measure the heights of the L surface and H surface in the step height reference and, as a result, obtaining the relationship between the output of the sensor and the specimen height, shown by the dash-dot line in Figure 4.

[0007]

When measuring the height of the specimen 303, the specimen height is found by interpolating or extrapolating the sensor output when the specimen 303 was measured using the relationship shown in Figure 4. For instance, in a case where output *a* is obtained as the result of measuring the specimen height, the output of the electron beam deflector is controlled with the specimen height, viewed as k1 μm.

[0008]

An example of this type of height-measuring device is disclosed in Japanese Kokai Patent Application No. Hei 2[1990]-6216.

[0009]

Problems to be solved by the invention

However, due to the increased intricacy of semiconductor devices in recent years, the drawing precision demanded of electron beam lithography equipment has increased. As a result, the tolerance for error in the lithography position shown by Δx in Figure 1 decreased to less than 0.1 μm, resulting in stricter demands for precision in height measurement. Therefore, there are instances in which past height-measuring device calibration methods have become unable to yield adequate precision. Namely, the relationship between changes in the specimen height and the

sensor output is not strictly linear, e.g., it has a characteristic like that shown by the solid line in Figure 4. Consequently, if the sensor output is a, the actual specimen height is k2 and deflector output must be controlled accordingly. In particular, since the error in k1 and k2 is greater than 0.5 μm when the reflected light radiates a spot away from the center of the position sensor 202, errors in k1, k2 that were negligible in the past can no longer be ignored when realizing high-precision lithography. The causes of this measurement error originate in the characteristics of the optical system from the light-emitting element 201 to the position sensor 202 and in the properties of the position sensor 202 itself. Thus, it has become difficult obtain adequate lithography results with the post calibration methods that use two reference surfaces.

[0010]

Means to solve the problems

In order to solve the aforementioned problems, a reference surface with an inclined surface, or a reference surface with three or more surfaces is prepared for calibration in the present invention, and the relationship between the position sensor output and the specimen height is found using this step height reference, which is approximated using a plurality of linear equations or quadratic or higher-order polynomials.

[0011]

Action

High-precision measurement is possible because the relationship between the position sensor output and the specimen height is approximated using a higher-order polynomial rather than a single linear equation.

[0012]

Embodiment

Figure 5 is an example in which a height-measuring device based on the present invention is employed in electron beam lithography equipment. The present invention will be described below, using this figure. The height of the specimen surface is measured by shining a light from a laser diode 201 onto the specimen 303, and sensing the light reflected by the specimen surface with a position sensor 202. Calculations to find the specimen height from the position of the light on the position sensor 202 when the height of the specimen has changed are performed by a height sensor control circuit 502.

[0013]

The height-measuring device is calibrated as follows. First, the details of the structure of the step height reference used for height calibration are shown in Figure 6. A structure 501 is provided in which two surfaces of different heights, surface L and surface H, are connected by an inclined surface. The results of continuously measuring the height of the step height reference thus structured, while moving the specimen table, are shown in the lower half of the figure. In the results obtained, the sensor output is discontinuous because the orientation of the reflected light changes at points w, x, y, and z, at which times the position of the measurement laser light moves from a flat surface to an inclined surface in the step height reference. Meanwhile, while there is an inclined surface with a constant slope between w and x, the sensor output is not proportionate to the height because the measuring device is not linear. This is the same for the reverse slope between y and z. The height in the inclined surface portions of the step height reference 501 can be determined from its slope and the position on the specimen table. A step height reference in which h = 200 μm and s = 30 mm was used in this embodiment. In past step height references, only the differences between N and O, and Q and R, were calibrated, but when the step height reference structured as shown in Figure 6 is used, a broader range of calibrations, i.e., between M and N, and P and O, are possible. In the control circuit 502, the differences between M and O, and P and R, are approximated with a three-dimensional curve from the sensor output to find the relationship between the sensor output and the specimen height, as shown in Figure 4.

[0014]

Height correction is performed during lithography as follows. Namely, since the output a shown in Figure 4 was obtained from the position sensor when the surface of the silicon wafer 303 that is the object of lithography was measured, the correct specimen height k2 was found from the relationship shown in this figure. The compensation quantities in values such as the electron beam deflection and lens current, etc., are calculated by the control computer 503, using the measurement results, the results of which are sent to the deflection control circuit 504 and lens control circuit 505, which make adjustments so that lithography can be performed under optimum conditions, after which, lithography is executed.

[0015]

An example in which a step height reference 701 with five different heights is used is shown in Figure 7 as another embodiment of the present invention. The calibration process comprises finding the height sensor output for each surface in the step height reference 701 shown in (a) of this figure, and then obtaining the 5 different outputs corresponding to each step height a-e, as shown in (b) of this figure. The differences between these various measurement points are

then approximated by the height sensor control circuit 502. Deflection and lens current correction is then performed and lithography is executed, based on the specimen height in the same manner as in the preceding embodiment.

[0016]

Effect of the invention

Since the calibration method takes the non-linearity of the height-measuring device, according to this method, high-precision height measurement becomes possible that was not possible with past devices.

Brief description of the figures

Figure 1 is an explanatory diagram of the relationship between the specimen height and lithography error.

Figure 2 is an explanatory diagram of the principles involved in the specimen height-measuring device.

Figure 3 is an explanatory diagram of a past specimen height-measuring device calibration method.

Figure 4 is an explanatory diagram of specimen height-measuring device calibration methods of the past and of the present invention.

Figure 5 is an explanatory diagram of an embodiment of the specimen height-measuring device of the present invention.

Figure 6 is an explanatory diagram of another embodiment of the specimen height-measuring device of the present invention.

Figure 7 is an explanatory diagram of another embodiment

Legend

501 ... Step height reference
502 ... Height-measuring device control circuit
503 ... Control computer
504 ... Reflection control circuit
505 ... Lens control circuit

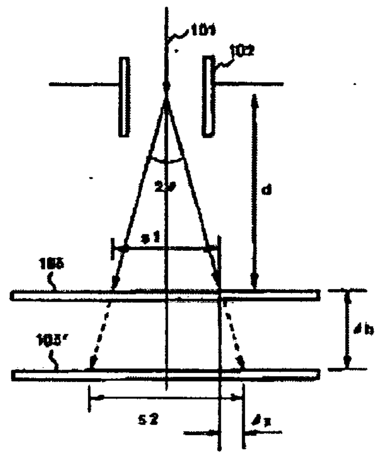

Figure 1

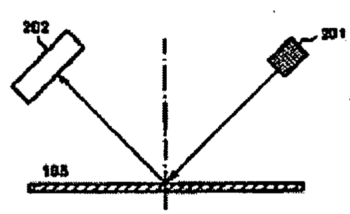

Figure 2

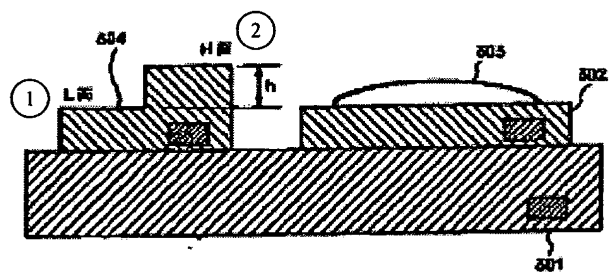

Figure 3

Key: 1 Surface L
2 Surface H

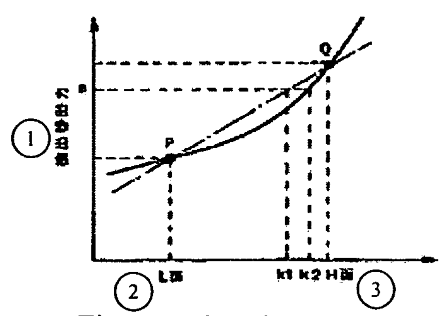

Figure 4. Specimen height

Key: 1 Sensor output
2 Surface L
3 k1 k2 Surface H

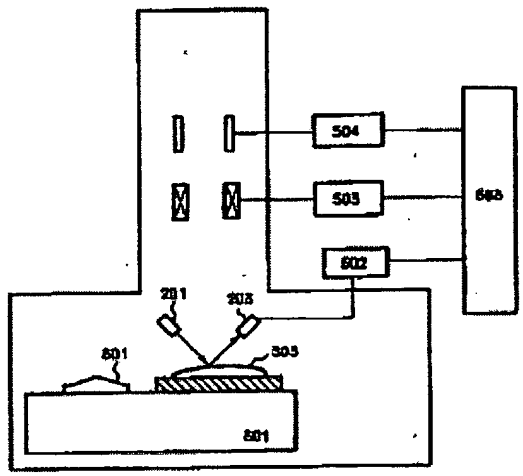

Figure 5

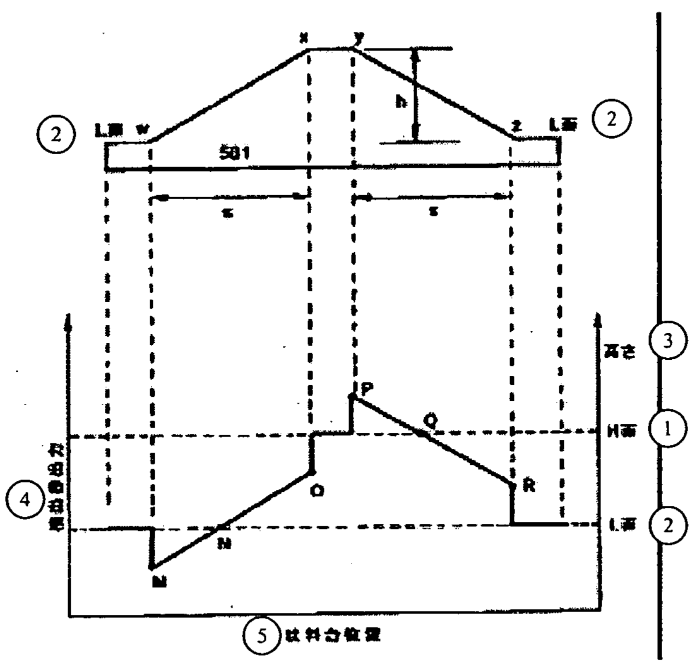

Figure 6

Key: 1 Surface H
2 Surface L
3 Height
4 Sensor
5 Specimen table position

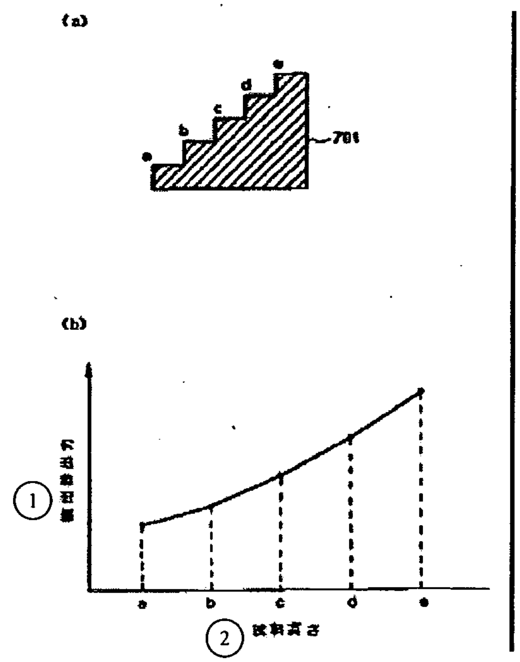

Figure 7

Key: 1 Sensor output
2 Specimen height